A paper prepared for the

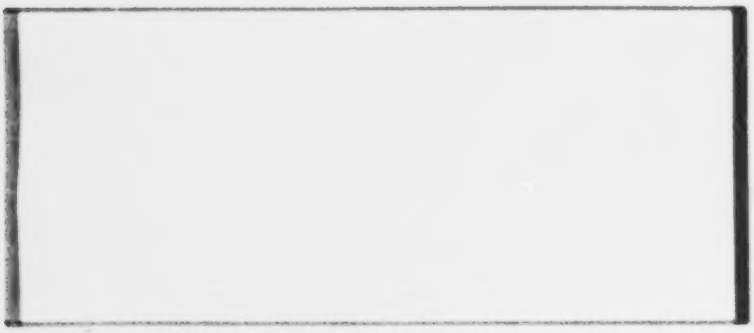
Un document préparé pour le

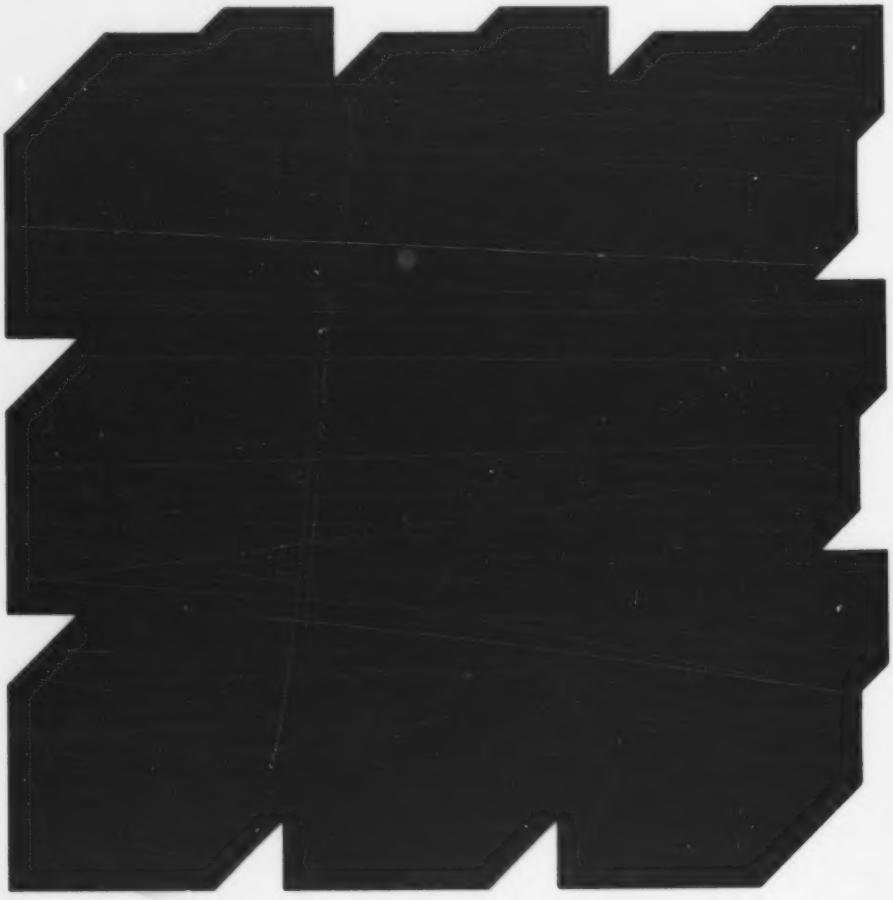
Economic Council of Canada

P.O. Box 527
Ottawa, Ontario
K1P 5V6

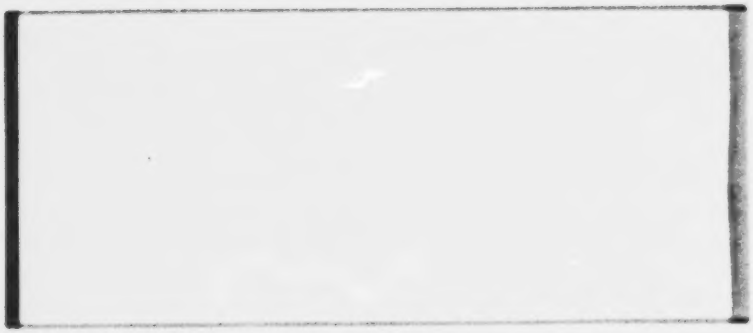
Conseil économique du Canada

C.P. 527
Ottawa (Ontario)
K1P 5V6





86-05071/



The **Economic Council of Canada** was established in 1963 by Act of Parliament. The Council is a crown corporation consisting of a Chairman, two Directors and not more than twenty-five Members appointed by the Governor in Council.

The Council is an independent advisory body with broad terms of reference to study, advise and report on a very wide range of matters relating to Canada's economic development. The Council is empowered to conduct studies and inquiries on its own initiative, or if directed to do so by the Minister, and to report on these activities. The Council is required to publish annually a review of medium- and long-term economic prospects and problems. In addition it may publish such other studies and reports as it sees fit.

The Chairman is the Chief Executive Officer of the Council and has supervision over and direction of the work and staff of the Council. The expenses of the Council are paid out of money appropriated by Parliament for the purpose.

The Council as a corporate body bears final responsibility for the *Annual Review*, and for certain other reports which are clearly designated as *Council Reports*. The Council also publishes *Research Studies, Discussion Papers* and *Conference Proceedings* which are clearly attributed to individual authors rather than the Council as a whole. While the Council establishes general policy regarding such studies, it is the Chairman of the Council who bears final responsibility for the decision to publish authored research studies, discussion papers and conference proceedings under the imprint of the Council. The Chairman, in reaching a judgment on the competence and relevance of each author-attributed study or paper, is advised by the two Directors. In addition, for *authored Research Studies* the Chairman and the two Directors weigh the views of expert outside readers who report in confidence on the quality of the work. Publication of an author-attributed study or paper signifies that it is deemed a competent treatment worthy of public consideration, but does not imply endorsement of conclusions or recommendations by either the Chairman or Council members.

Établi en 1963 par une Loi du Parlement, le **Conseil économique du Canada** est une corporation de la Couronne composée d'un président, de deux directeurs et d'au plus vingt-cinq autres membres, qui sont nommés par le gouverneur en conseil.

Le Conseil est un organisme consultatif indépendant dont le mandat lui enjoint de faire des études, donner des avis et dresser des rapports concernant une grande variété de questions rattachées au développement économique du Canada. Le Conseil est autorisé à entreprendre des études et des enquêtes, de sa propre initiative ou à la demande du Ministre, et à faire rapport de ses activités. Chaque année, il doit préparer et faire publier un exposé sur les perspectives et les problèmes économiques à long et à moyen termes. Il peut aussi faire publier les études et les rapports dont la publication lui semble opportune.

Le président est le directeur général du Conseil; il en surveille les travaux et en dirige le personnel. Les montants requis pour acquitter les dépenses du Conseil sont prélevés sur les crédits que le Parlement vote à cette fin.

En tant que personne morale, le Conseil assume l'entière responsabilité des *Exposés annuels*, ainsi que de certains autres rapports qui sont clairement désignés comme étant des *Rapports du Conseil*. Figurent également au nombre des publications du Conseil, les *Études*, *Documents* et *Comptes rendus de colloques*, qui sont explicitement *attribués à des auteurs particuliers* plutôt qu'au Conseil lui-même. Celui-ci établit une politique générale touchant ces textes, mais c'est au président qu'il incombe de prendre la décision finale de faire publier, sous les auspices du Conseil économique du Canada, les ouvrages à nom d'auteur tels que les études, documents et rapports de colloques. Pour se prononcer sur la qualité, l'exactitude et l'objectivité d'une étude ou d'un document attribué à son auteur, le président est conseillé par les deux directeurs. De plus, dans le cas des *études à nom d'auteur*, le président et les deux directeurs sollicitent l'avis de lecteurs extérieurs spécialisés, qui font un rapport confidentiel sur la qualité de ces ouvrages. Le fait de publier une étude ou un document à nom d'auteur ne signifie pas que le président ou les membres du Conseil souscrivent aux conclusions ou recommandations contenues dans l'ouvrage, mais plutôt que l'analyse est jugée d'une qualité suffisante pour être portée à l'attention du public.

DISCUSSION PAPER NO. 311

Micro-Computer Simulation with a General Equilibrium Model of Canada

by Sylvester Damus

The findings of this Discussion Paper are the personal responsibility of the author and, as such, have not been endorsed by the members of the Economic Council of Canada.

Discussion Papers are working documents made available by the Council, in limited number and in the language of preparation, to interested individuals for the benefit of their professional comments.

La série "Documents" contient des documents de travail dont le Conseil fait une diffusion restreinte, dans leur version d'origine, en vue de susciter des commentaires de la part de spécialistes.

Requests for permission to reproduce or excerpt this material should be addressed to:

Director of Information
Economic Council of Canada
Post Office Box 527
Ottawa, Ontario
K1P 5V6

ISSN-0225-8013

August 1986

RÉSUMÉ

Le présent document contient la description d'un modèle d'équilibre général servant à l'analyse et à la simulation de la politique fiscale canadienne. Il présente la structure du modèle, les sources de données, ainsi que les méthodes de calibration et de solution et, en guise de conclusion, certaines simulations préliminaires d'une taxe sur la valeur ajoutée prélevée sur une assiette égale au produit national brut.

SUMMARY

This paper is documentation of a general equilibrium model for analysis and simulation of Canadian tax policy. It presents the model structure, data sources, calibration and solution methods, and concludes with some preliminary simulations of a GNP-type Value-Added-Tax.

CONTENTS

	Page
INTRODUCTION	1
1 GENERAL DESCRIPTION OF THE MODEL	3
2 EQUATIONS	9
2.1 Model Symbols	17
2.2 List of Variables	21
2.3 Parameters	23
2.4 Parameter Restrictions	25
2.5 Model Equations	27
3 DATA	33
3.1 Data Sources	35
4 CONSISTENCY OF THE MODEL WITH NATIONAL ACCOUNTS	39
5 AGGREGATION	45
5.1 Squaring	50
6 CALIBRATION	53
6.1 Pre-Calibration	54
6.2 Calibration	58
7 POLICY CHANGES	61
8 SOLUTION	63
8.1 Solution Set-up	63
8.2 Solution Algorithm	64
9 TAX SIMULATIONS	67
9.1 Calibration Assumptions	73
9.2 Results	74
APPENDIX A: Programs and files	85
APPENDIX B: Sample output	89
BIBLIOGRAPHY	93

LIST OF TABLES

		Page
1	3-industry, 1980 Tax Simulations	75
2	16-industry, 1980 Tax Simulations	76
3	42-industry, 1980 Tax Simulations	77
4	Simple Correlations Between Tax Rates, 1980	79
5	Effects of MST and VAT on Canadian Trade, 1980	82
6	Losses due to terms of trade deterioration	84

LIST OF ILLUSTRATIONS

1	Program Flow Chart	86
2	Data File Structure	87

ACKNOWLEDGEMENT

Thanks are due to Wayne Thirsk for numerous comments on a previous draft. Remaining errors are, of course, mine alone.

INTRODUCTION

In this paper I present a new addition to a growing list of general equilibrium models of Canada [Ballentine and Thirsk; Boadway and Treddenick; Damus; Damus, Hobson and Thirsk; Harris and Cox; Jenkins and Kuo; Hamilton and Whalley; and Norrie and Percy].

The distinguishing feature of this new model is that it is perhaps the first micro-computer implementation of a general equilibrium model.

The advantage from having a micro-computer model is in the freedom it gives one from the frequent and justified feeling that simulation results are derived from a "black box" or pulled like rabbits from a hat. General equilibrium results are usually reported in specialized journal articles or in scholarly books. Inevitable space limitations suffered by articles militate against a clear communication of general equilibrium techniques and of the sensitivity of results to alternative assumptions. Books and monographs can be more informative but their publication lags detract from their policy interest. In every case, replication of published results, analysis of their sensitivity to key assumptions, and fuller understanding of the behaviour of models

are impeded by the lack of computer code, by the cost of computing, or simply by lack of access to data and computers.

Computing is one of the nearest substitutes for a laboratory that an economist can have. Experimentation with computer models can be as vital to the economist as laboratory work is to every other scientist. Such work is essential to gain understanding of theoretical principles and empirical facts. The advantage of running a model that gives results on one's own desk in a matter of seconds and at no incremental cost can therefore not be over-estimated. In addition, the version presented here makes the data and their use as transparent as possible and lets one follow on screen revisions of key variables made in the approach to a solution.

The purpose of this paper is to document the model structure, data sources, calibration and solution. The solution will be illustrated with preliminary results of Value-Added Tax simulations. The tentative conclusion from these simulations is that tax neutrality pays but will not be achieved by simply switching to a single-rate Value Added Tax. Furthermore, the effects of this tax seem to be highly dependent on the level of industrial aggregation that is applied in the analysis.

1 GENERAL DESCRIPTION OF THE MODEL

This is a disaggregated open economy model with variable factor supplies and a government sector. In many respects, it is similar to my previous (1984) version except that it has been extended in various ways and the debt/equity finance equations have been dropped.

On the production side, the model can have up to 43 industries. Various government enterprises are included in the relevant industries. All industries are assumed to operate under constant returns to scale. Two different production functions are modeled for them. Most industries have a separable production function that has constant elasticity of substitution of capital for labour and additive, linear intermediate input requirements. There can also be up to three "dummy industries" that employ no primary factors. They have a linear production function of intermediate inputs only and are included in the system to route bundles of uncertain commodity content as inputs into industries, or to account for margins between producers' and purchasers' prices that can be represented as additional commodity purchases.

The demand side of the model can be disaggregated into ten household groups, each representing a particular decile in the income distribution. There is also a consolidated (local,

provincial and federal) government sector. Household incomes are derived from factor supplies to industry and government and are supplemented by government transfer payments. Government expenditure equals total tax revenue from all sources less transfers to households and subsidies to industry. Government is modeled as having no factor income. Resource royalties are correspondingly treated as a commodity tax. Tax revenue not transferred back to households is used by government to purchase commodities and primary factor services.

Transfer payments to households are excluded from taxable income although this is true of only one-third of such transfers. Government -- but not government enterprises -- is modeled as tax exempt. Government purchases are not subject to factor or commodity taxes.

Taxes fall into basically three types: those that distort the choice of factor inputs, those that distort consumption choices, and those that distort factor supplies. Corporate income tax, payroll taxes and property taxes are modeled as taxes distorting the relative factor prices faced by industry and the industries' choices of capital/ labour ratios.

Sales taxes, import duties, export levies, royalties, and subsidies distort commodity prices. Sales taxes on intermediate

input transactions are included here because the fixed input coefficients assumption implies that these taxes float up to the producer price level.

Factor supplies are variable as a result of a labour/leisure choice of households and international capital flows. The labour/leisure choice can be distorted by a linear, progressive personal income tax, by transfer payments and by commodity taxes.

With regard to foreign capital, I model only the service flow on current account. Following Ballentine and Thirsk, it is assumed that the equilibrium flow on capital account is zero. Differences in the levels of services flowing in a base case and a simulated solution would imply an intervening non-zero flow on capital account. This being a static model without transactions in assets, the transition from one equilibrium to another and the accompanying transactions on capital account are omitted.

A non-resident withholding tax is included. This tax is assumed to be fully creditable against taxes in the non-resident's country. It therefore has no effect on capital service flows but it does affect the overall trade balance. These flows react to a cross-border differential in after-tax capital rental prices and can assume negative values (for service outflows).

The foreign sector is closed by the assumption of finite export demand elasticities, fixed import content of Canadian products, substitution of imports for Canadian products in final demand, and a current account balance condition.

The import contents of intermediate and final demands have fixed price elasticity, as in Armington [1969]. Import demand price elasticities are also derived from the elasticities in final demands. The finite export demand elasticities reflect a "large-open-economy" assumption. They allow modeling of two-way commodity trade and can imply terms-of-trade effects of tax policies.

The analysis of welfare change from a policy is made by evaluation of Hicksian compensating and equivalent variations under constant elasticity of substitution utility functions.

Household utility is a function of goods purchased and of leisure. The goods include both consumption and investment goods. The latter may be said to yield instant gratification proportional to the present value of future consumption goods that they represent.

There is also a "government utility" which is a function of commodities and primary factor services purchased by government

for non-industrial use. Following Krauss and Johnson, this can be viewed as a separable private utility of public goods.

The fact that the private utility of public goods is separable from that of private goods means that the model misses a potentially important distortion, namely the mis-allocation of resources between the private and public sectors (by over- or under-funding of government). A general equilibrium model where public goods yield private utility and the household's marginal evaluation of private relative to public goods can be distorted is reported on elsewhere [Damus, Hobson and Thirsk].

In the present model, transfer payments can be adjusted to hold constant the utility of government expenditures. The model is "real" in the sense that only relative prices matter. All money prices are normalized on GNP so that the dollar value of GNP remains constant in every simulation. Assumptions and their roles are discussed further in the next chapter on model equations and in Chapter 6 on calibration.

2 EQUATIONS

The principal equations are those expressing production relations, consumer utility, and the export and import demands.

Two considerations governed the choice of functional forms for these equations. One is that they be capable of expressing various elasticities of substitution between factors of production and between consumer goods. The other is that they have as few parameters as possible. These two criteria suggest the constant-elasticity-of-substitution (CES) form. This has fewer parameters than the alternatives, with the exception of the Cobb-Douglas function that does not allow substitution elasticities other than unitary. The CES form is applied to production and utility functions. In the latter case I use a nested CES, that is, a function that is a CES-function of another CES function. The "lower nest" is a function of goods and services in final demand.

The arguments in the overall utility function are leisure and the CES function of goods and services. Such a nested function has two elasticities of substitution. One is the elasticity of substitution of one good for another. The other is the elasticity of substitution of leisure for the nested bundle of goods (i.e.,

income). The production functions are not nested, there being only two primary factors.

The CES form is applied flexibly in the sense that the number of arguments can vary depending on the base case purchases by industries or consumers. Owner-occupied housing, for instance, does not use labour. In this case the CES form is abandoned and output is treated as directly proportional to capital input. Some consumers (including government) do not purchase the products of every industry. The products they do not purchase are omitted from their individual utility functions.

Foreign economies are not modeled explicitly. World market prices of import goods, of goods that are imperfect substitutes for Canadian exports, and of the services of capital are exogenous. Foreign responses to changes in Canadian prices relative to world market prices are modeled by their demands for Canadian exports and their supply of capital services to Canada. Canadian prices of tradeable goods and services are endogenous. The alternative to this treatment is a fixed-price, "small-open-economy" model. However, the number of imperfectly mobile, primary factors of production in such a model would have to be equal to the number of tradeables. The empirical base for data and behavioural assumptions relating to additional primary factors is very weak and, therefore, a small economy model could

not have any more than perhaps three factors and thus three tradeables without running into serious data problems.

The export demands have constant price elasticities and the price variable is the ratio of Canadian dollar export prices to foreign-currency world market prices converted -- with an exchange rate -- to Canadian dollars. The capital supply is a variable-elasticity function that allows change in the direction of the service flow. The direction depends on the relative height of the rental price of capital in Canada compared to what capital fetches abroad after conversion to Canadian dollars.

The import-content of intermediate demand has no price-elasticity. The import-content of final demand is a constant-elacticity function of the ratio of domestic to foreign prices. Since empirical values of these elasticities are likely to be the scarcest of all inputs to the model, I have decided to exclude them from any role in the calibration. Instead, a single value of this elasticity can be entered immediately prior to model solution and is then applied equally to all import demand functions. Its default value is zero, as implied in the list of equations below. A common effect of assuming and entering a value greater than zero is to reduce the economic gains from unilateral free trade.

If the elasticity of substitution of imports in final demand were left at zero, the demand for imports would depend mostly on the exchange rate. An increased Canadian dollar price of an import good would decrease its demand directly by raising the cost of the import content of a good in final demand, and therefore its price. It also reduces demand indirectly by raising the cost of the import content of domestic output and therefore also the price of Canadian products.

The exporting industries are all those that showed gross exports in the base case year. This model does not deal in net exports (exports minus imports) but in genuine two-way trade. An important feature of the trade of Canada is the trade in automobiles and parts under the Canada-U.S. auto pact. Because of this pact, motor vehicles and parts are both imported and exported. A model that netted out imports and exports would not capture this feature of the Canadian economy. Depending on which year was chosen as a base case, such a model would treat motor vehicles and parts as either an import good or as an export good, not both. This model treats this and other, lesser items in our foreign trade as both an import and an export.

Another reason to model two-way trade is that it makes it easier to account correctly for government revenue in a tax model and for import duty revenue in a trade model. During 1980, Canada collected about $3.1 billion in duty revenues on approximately

$75 billion of gross imports. Exports exceeded imports by about $6 billion and so, in a one-industry model in which imports and exports were netted out, there would have been that much in net exports and no net imports. Such a model could not account for the actual duty revenue without either implying an infinite rate of duty or deleting duty revenue from total tax revenue. In a multi-sector model, duty rates computed as ratios over net imports by some sectors would still be excessive in comparison with actual rates charged. On the other hand, if these rates were used in the model, the duty revenue would be less than the actual one. In short, the accounting for duty revenue is more satisfactory in a two-way trade model than in one where imports and exports are netted out.

Realism in modeling is not without cost, however. Two-way trade cannot be modeled unless it is assumed that goods of domestic and foreign origin are imperfect substitutes that do not fetch identical prices. Trading countries are completely specialized in production; only Canada produces Canadian goods and Canada does not reproduce what the rest of the world supplies. Moreover, the pattern of specialization is not affected by economic and policy variables. The trade model is thus close to a pre-Recardian model of trade with absolute advantages of the trading partners in the supply of specialized goods. Alternatively, this model's foreign sector can be considered to be an approximation to the new

theories of intra-industry trade that do not rely on scale economies to explain such trade.

One implication of absolute advantage is that any policy can have strong effects on the terms-of-trade. Tariffs, in particular, may benefit a country by so improving its terms-of-trade that the losses imposed on consumers of imported goods are reversed. Furthermore, since domestic and foreign goods do not fetch identical prices, the model must explain twice as may prices than it otherwise would have to. It has to grind out prices of goods made in Canada that are different from the exogenous world market prices of similar goods. Such cannot be done unless the elasticities of export demand and capital supply are relatively small. It certainly could not be done if such elasticities were postulated to be very large, meaning that the Canadian economy has no appreciable effect on commodity and capital prices. In practice, however, it cannot be done even if these elasticities rise above twelve in absolute value or so. The exact point at which the model chokes on excessive elasticities cannot be determined precisely; it depends on the precise shape of the constellation of export demand and capital service supply elasticities. This limitation on the size of trade elasticities is a cost of modeling two-way trade.

The import content of Canadian production finds expression in a matrix of intermediate good inputs of foreign origin. This is

paralleled by a similar matrix of intermediate good inputs of domestic origin. Both matrices represent a large number of linear relations between industries that provide further description of the production process beyond that given by the CES production functions. For three industries, these linear interindustry relations are all there is to describe their production process. These are the so-called "dummy industries" that employ no primary factors and are not meant to represent any actual, identifiable industry. They are carried along in the model to account for purchases by industry and households of goods and services that cannot be allocated to industry outputs without further information. These dummy industries are an artifact of Statistics Canada's input-output analysis that is preserved here.

Personal income tax payments by household groups are determined by a linear function. Its slope is the marginal personal income tax rate and the negative intercept makes this tax progressive. Thus every household faces a different average but the same marginal rate. The application of the same constant to all households requires that household groups be held equal in population size. The alternative and more common procedure is to determine average tax rates from the data and assume that the marginal ones are equal to them. Household behaviour is thus modeled as one responding to average tax rates and these rates would not change as household income changes. Since tax rates are specific to households and not to income levels, no attention

needs to be paid to the sizes of household groups in this case. With the present formulation, households are explicitly modeled as responding to the marginal rate and the average rates of tax on them are changed every time household incomes change. This also causes a slight simplification of the computations and speeds them up a little. Each of these two alternative formulations of the personal income tax has its advantages and disadvantages. The balance in favour of the one adopted here could be strengthened by introducing a non-linear function but that will have to await further research.

The equations discussed in this section are displayed below, in section 2.5. Other equations are generally in the nature of budget constraints or equations derived from the production and utility functions and perhaps do not merit further comment. Preceding them are lists of model variables and parameters, and of parameter restrictions. Most restrictions are inoffensive except those on production and utility function share parameters. These can become binding as soon as industries are finely disaggregated. Two such cases have been mentioned already: one where owner-occupied housing is not employing labour and therefore the CES form is not applied to its production function; the other where households or government violate the non-negativity condition on the alphas and therefore the corresponding good or service is dropped from a utility function. This is discussed further in section 6.1, point 14.

2.1 Model Symbols

a constant term in the linear personal income-tax schedule

a_{ji} domestic input coefficient (use of j-th input of domestic origin per unit of output of the i-th product)

A_{ji} intermediate use of good j in production of good i

c foreign capital supply shift parameter

D_i final demand by residents

e exchange rate (in units of domestic currency per unit of foreign currency)

E_i exports

F foreign capital service flow

g foreign capital supply elasticity parameter

G government imports

G_L final demand for labour by government

G_K final demand for capital by government

$\bar{K}_j$ capital endowment of j-th resident

K_i capital input to industry i

$\bar{L}_j$ labour endowment of j-th resident

L_i labour input to industry i

m number of resident consumers

M_i imports of good i

n number of industries

N_j leisure of j-th consumer

p_i producer price

P_i consumer price excluding retail sales tax

q_i world market price expressed in foreign currency

Q_i industry gross output

r	rental rate of capital net of corporate income tax
t_i^e	export tax rate
t^f	non-resident withholding tax rate (assumed to be fully creditable by the foreign tax authorities)
t_i	retail sales tax rate
t_{ji}	rate of sales tax on intermediate inputs
t_{ki}	corporate income tax rate (including property taxes)
t_{li}	payroll tax rate
t_i^m	rate of import duty on duty-paid value
t^y	marginal personal income-tax rate
T	total tax revenue
U_i	individual utility
v_i	rate of other commodity taxes net of subsidies (including royalties)

w	wage rate
W	total transfer payments
X_{ji}	demand of i-th good by the j-th consumer
Y_j	personal, taxable income
Z_j	disposable income
α_{ji}	j-th consumer's expenditure share parameter for the i-th good
β_j	elasticity of substitution among goods in consumption by the j-th consumer
γ_j	leisure demand share parameter
δ_i	factor-income-distribution parameter
ϵ_i	export demand shift parameter
η_i	export demand elasticity
μ_i	import content of final demand

μ_{ij} import content of intermediate demand

π rental price of capital abroad, in foreign currency

ϕ_i industry productivity parameter

ρ_i factor substitution parameter

σ_i elasticity of substitution of capital for labour in production

τ_j j-th consumer's share in total transfer payments

ω_j elasticity of substitution of leisure for goods and services

2.2 List of Variables

Variable symbol	Number
A_{ji}	n^2
D_i	n
e	1
E_i	n

F		1
G	exogenous	
G_K		1
G_L		1
G		
K_i		n
L_i		n
M_i		n
N_j		m
p_i		n
P_i		n
q_i	exogenous	
Q_i		n

r	1
T	1
U_i	m+1
w	1
W	1
X_{ji}	n(m+1)
Y_j	m
Z_j	$\frac{m+1}{n^2+9n+nm+4m+10}$

2.3 Parameters

Assumed	Calibrated
a	a_{ji}
g	c
t^y	$\bar{K}_j$

Assumed	Calibrated
β_j	$\bar{L}_j$
η_i	t_i^e
π	t^f
σ_i	t^i
ω_j	t_{ji}
	t_{ki}
	t_{li}
	t_i^m
	v_i
	α_{ji}
	γ_j
	δ_i
	ε_i

μ_i

μ_{ij}

ϕ_i

ρ_i

τ_j

2.4 Parameter Restrictions

$a_{ji} > 0$

$c > 0$

$g < 0$

$m = 1, 2, 5 \text{ or } 10$

$n = 2, \ldots, 43$

$\sum_{j=1}^{n} a_{ji} < 1$

$t^f < 1$

$t_i^m < 1$

$\alpha_{ji} > 0 \qquad \sum_{i=1}^{n} \alpha_{ji} = 1$

$0 < \gamma_j < 1$

$0 < \delta_i < 1$

$\varepsilon_i > 0$

$\eta_i < 0$

$0 < \mu_i < 1$

$0 < \mu_{ij} < 1$

$\phi_i > 0$

$\sigma_i > 0 \qquad \sigma_i \neq 1$

$\beta_j > 0 \qquad \beta_j \neq 1$

$\omega_j > 0 \qquad \omega_j \neq 1$

$\sum_{j=1}^{m+1} \tau_j = 1$

2.5 Model Equations

Production functions

$$Q_i = \left[\phi_i \, \delta_i L_i^{-\rho_i} + (1-\delta_i) K_i^{-\rho_i} \right]^{-1/\rho_i}$$

$$= A_{ji}/a_{ji}; \qquad i = 1 \text{ to } n$$

$$j = 1 \text{ to } n$$

Utility functions of households

$$U_i = \left\{ (1-\gamma_i)^{1/\omega_i} \left[\sum_{j=1}^{n} \alpha_{ij}^{1/\beta_i} X_{ij}^{1-1/\beta_i} \right]^{\beta_i/(\beta_i-1)} \right\}^{1-1/\omega_i} +$$

$$\left\{ \gamma_i^{1/\omega_i} N_i^{1-1/\omega_i} \right\}^{\omega_i/(\omega_i-1)}$$

$$i = 1 \text{ to } m$$

$$j = 1 \text{ to } n$$

Government utility

$$U_{m+1} = \left[\sum_{j=1}^{n+2} \alpha_{m+1,j}^{1/\beta_{m+1}} X_{m+1,j}^{1-1/\beta_{m+1}} \right]^{\beta_{m+1}/(\beta_{m+1}-1)}$$

where the summation is over commodities 1 to n, labour (n + 1) and capital (n + 2).

Supply of foreign capital services

$$F = c\left[1-\left(\frac{r}{\pi e}\right)^{g}\right] \qquad (F<0 \text{ if } r<\pi e)$$

Marginal condition for cost minimization in production

$$\frac{L_i}{K_i} = \left[\frac{\delta_i}{1-\delta_i}\left(\frac{1+t_{ki}}{1+t_{li}}\right)\frac{r}{w}\right]^{\sigma_i} \qquad i = 1 \text{ to } n$$

Factor market equilibria

$$F + \sum_{j=1}^{m} \bar{K}_j = \sum_{i=1}^{n} K_i + G_K$$

$$\sum_{j=1}^{m} (\bar{L}_j - N_j) = \sum_{i=1}^{n} L_i + G_L$$

Producer prices

$$p_i = [w(1+t_{li})L_i + r(1+t_{ki})K_i]/Q_i$$

$$+ \sum_{j} \mu_{ji}\,(1+t_{ji})a_{ji}\; e\; q_j/(1-t_i^m)$$

$$+ \sum_{j} (1-\mu_{ji})(1+t_{ji})a_{ji}\; p_j + v_i p_i$$

Final demands by residents

$$D_i = Q_i + M_i - E_i - \sum_j A_{ij}$$

Export demands

$$E_i = \varepsilon_i \left[\frac{p_i(1+t_i^e)}{q_i e} \right]^{\eta_i} \qquad (\eta_i < 0)$$

Import demands

$$\mu_{ij} = M_i/(Q_i - E_i + M_i)$$

$$\mu_i = (M_i - \sum_j \mu_{ij} A_{ij})/D_i$$

Balance of payments

$$\sum_i p_i(1+t_i^e)E_i - e \sum_i q_i M_i/(1-t_i^m) - r(1-t^f)F - G = 0$$

Consumer prices before sales tax

$$P_i = (1-\mu_i)p_i + \mu_i eq_i/(1-t_i^m)$$

Government revenue

$$T = r \sum_i t_{ki} K_i + w \sum_i t_{li} L_i$$

$$+ (D_i - X_{m+1,i}) P_i \, t_i$$

$$+ eq_i \, M_i \, t_i^m / (1 - t_i^m)$$

$$+ p_i \, t_i^e \, E_i + p_i \, Q_i \, v_i$$

$$+ \sum_{i=1}^{n} \sum_{j=1}^{n} (1 - \mu_{ji}) \, A_{ji} \, p_j \, t_{ji}$$

$$+ e \sum_{i=1}^{n} \sum_{j=1}^{n} \mu_{ji} \, A_{ji} \, q_j \, t_{ji} / (1 - t_i^m)$$

$$+ r \, t^f \, F + \sum_j (a + t^y Y_j)$$

Personal income

$$Y_j = r\bar{K}_j + w(\bar{L}_j - N_j) \qquad (j = 1 \text{ to } m)$$

$$Y_{m+1} = 0$$

Transfer payments

$$W = T - G$$

Disposable incomes of households and government

$$Z_j = -a + (1-t^Y)Y_j + \tau_j W \qquad (j = 1 \text{ to } m)$$

$$Z_{m+1} = \tau_{m+1} W$$

Consumer demands

$$X_{ji} = \alpha_{ji} Z_j / [(s_i P_i)^{\beta_j} \sum_{i=1}^{n'} \alpha_{ji} (s_i P_i)^{1-\beta_j}]$$

$n' = n$; $s_i = 1 + t_i$ if $j < m+1$ (for household demands)

$n' = n+2$; $X_j n+1 = G_K$; $X_j n+2 = G_L$ $s_i = 1$ if $j = m+1$ (for government)

Intermediate demands

$$A_{ij} = a_{ij} Q_j$$

Market Equilibrium

$$D_i = \sum_{j=1}^{m+1} X_{ji} \qquad (i = 1 \text{ to } n)$$

Sub-utility function nested in household utility

$$S_i = \left[\sum_{j=1}^{n} \alpha_{ij}^{1/\beta_i} X_{ij}^{1-1/\beta_i} \right]^{\beta_i/(\beta_i-1)}$$

Marginal condition on labour/leisure choices

$$(N_i/S_i) = [\gamma_i/(1-\gamma_i)] \{Z_i/[1-t^y)w S_i]\}^{\omega_i}$$

$$N_i \leq \bar{L}_i \qquad (i = 1 \text{ to } m)$$

and where the term under the exponent is the cost of living relative to the after-tax wage.

Gross National Product

$$GNP = \sum_{j=1}^{m+1} Z_j$$

Gross Domestic Product

$$GDP = r F + GNP$$

3 DATA

The data for the model are assembled from Statistics Canada publications, tapes, and special tabulations. These data are copied to computer files of matrices organized by rows and columns. The required matrices are outlined below and the data sources are listed in the next section.

While all data are obtained from one source, they are not always mutually consistent. For instance, incomes and expenditures derived from household surveys cannot be expected to add up to the same totals as input-output data and, while the latter are gathered at the establishment level, financial data such as corporate income taxes paid are at the industry level. There seems to be no best way to resolve the implied inconsistencies but resolved they must be. This is discussed further in Chapters 6 and 9 on calibration and tax simulations.

Make Matrix	43 industry columns; 92 commodity rows; An element at the intersection of a column with a row shows industry output of a commodity.
Use Matrix	43 industry columns; 92 commodity rows;

	9 value-added rows. An element shows the amount of an input in the row used by an industry in the column.
Final Demand Matrix	29 demand categories; (consumption, investment, exports, imports and government); 92 commodity rows; 8 value-added rows.
Taxes Matrix	43 industry columns; 4 tax rows: non-commodity taxes, payroll taxes, corporate income taxes, royalties.
Family Expenditures	10 household columns (by decile, ranked by income in ascending order); 14 expenditure categories.
Endowments	10 household columns; 4 rows: net worth, weeks worked, number of adults, family labour income.

Margins	1 column of federal sales tax revenue and some provincial taxes; 92 commodity rows; 8 value-added rows.
Export Tax	1 column of export levy revenue; 92 commodity rows.
Property tax Revenue Withholding Tax Revenue Personal Income Tax Revenue	
Import Duty Revenue	1 column with 92 commodity rows and 8 value-added rows.

3.1 Data Sources

Make, Use, and Final Demand Matrices: Statistics Canada, The Input-Output Structure of the Canadian Economy, Catalogue No. 15-201.

Non-commodity taxes by industry, royalties paid by industry, margins and export tax revenue: Statistics Canada, System of National Accounts Branch, Input-Output Division, special tabulations.

Payroll taxes by industry: Statistics Canada, Labour and Household Surveys Branch, Labour Division, special tabulation.

Corporate income taxes: Statistics Canada, Corporation Taxation Statistics, Catalogue No. 61-208, Table 10.

Family expenditures: Statistics Canada, Income and Expenditure Division, Survey of Family Expenditures, micro data file on public use tape.

Net Worth: Statistics Canada, Consumer Income and Expenditure Division, Survey of Consumer Finances, Income, Assets and Debts of Economic Families and Unattached Individuals, micro data file on public use tape.

Weeks worked, number of adults and earned income: Statistics Canada, Consumer Income and Expenditure Division, Survey of Consumer Finances, micro data file on public use tape.

Property tax revenue: Statistics Canada, National Income and Expenditure Accounts, Catalogue No. 13-201, Table 46, rows 13 and 20.

Withholding taxes: Statistics Canada, National Income and Expenditure Accounts, Catalogue No. 13-201, Table 43, row 10.

Personal income tax revenue: Statistics Canada, National Income and Expenditure Accounts, Catalogue No. 13-201, Table 43, rows 1 and 2.

Import duty revenue: Lorey Hoffman, Department of Finance, Commodity Tax Section, "Applied General Equilibrium Tax Models: External Sector Data (Medium Dimension), mimeo, 1984.

4 CONSISTENCY OF THE MODEL DATA WITH NATIONAL ACCOUNTS

The input-output tables in the system of national accounts provide the main framework for analysis and most of the data. Since the input-output tables are a perfectly consistent set of accounts there should be no need to bend data into consistency with published accounts.

The model data do, however, deviate slightly from published accounts for the following reasons:

1. Suppression of confidential data from the published input-output accounts; and

2. Failure to model certain input-output transactions.

3. 43-industry aggregation of the data input.

One discrepancy appears in the 1980 use table. Whereas, the published total use of primary factors and commodities is $505,350 millions, the corresponding total in the model data base is $503,370 millions. The (0.4 per cent) difference is entirely accounted for by exclusion from the model of non-competing imports and of unallocated imports and exports. As for other commodities, the detail of use by industry differs only by the transfer of government royalties on natural resources out of the real estate service row and into an indirect tax row.

Most other discrepancies appear in the Final Demand table. The first of these arises from the fact that the sum of the entries in this table ($302,900,4 millions) does not agree with the published total ($305,691,3 millions), presumably because of suppression of confidential commodities. Most of this discrepancy arises at the intersection of the Industrial Chemicals and Fertilizer rows (rows 64 and 65) with the Exports column.

	1980 Final Export Demand
	($ millions)
Published Sum	86,184,3
Sum of detail in rows	83,394,6
Difference	2,789,8

The difference in the export column is $2,789,8 millions, whereas the total difference in the Final Demand table is $2,790,4 millions. This is made up as follows:

	1980 Final Demand Row Sums		
	As Published	Sum Over the Columns	Difference
		($ millions)	
64 Industrial Chemicals	-218,7	-2,013,5	1,794,8
65 Fertilizers	955,9	- 39,7	995,6
Total	737,2	-2,053,2	2,790,4

There is also a $12 million difference between indirect taxes on exports and export levies included in the Margins table detail by commodity.

Model-equivalent final demands deviate further from published totals by the exclusion of some final demands from the model. Beyond that, further discrepancies arise in the details of industry supplies to final purchasers.

However, these differences in detail affect only the distribution of final demands and not their total.

	1980 Final Demand		
	Published I/O Tables	Model	Difference
		($ millions)	
Private Sector	160,036,5	160,841,0	804,5
Exports	86,184,4	78,820,3	-7,364,1
Government	59,470,4	58,763,4	- 707,0
	305,691,3	298,424,7	-7,277,6

The difference in the government row is due to the combination of negative net demands with CES utility assumptions. The arguments of CES functions cannot be negative and, therefore, whenever a net demand is negative, it is forced to equal zero during calibration. Demands by other purchasers are correspondingly reduced to maintain the total.

In 1980, withdrawals from inventory are a source of negative demands by the private sector even at the small aggregation (16-industry) level. Forcing these to zero while maintaining the totals required a reduction of demands by government by $707 millions. Some government demands have also been forced to zero and so this latter figure represents re-distribution between private and public sectors.

The discrepancy in the total of all final demands is accounted for as follows:

	Differences in 1980 Final Demand
	($ millions)
Due to:	
Exclusion of Private Sector FD for Primary Factors	6,423,6
Exclusion of Unallocated Imports and Exports and of Non-competing Imports	-1,979,2
Exclusion of Export Taxes from the Margins	12,0
Suppression of Confidential Export Commodities	2,789,8
Suppression of Other Confidential Data and Rounding Errors	24,4
TOTAL DISCREPANCY	7,266,6

Finally, the 43-industry aggregation of the data causes some discrepancies in the distribution of commodity tax margins between final and intermediate uses. The division of tax margins between intermediate and final transactions can overstate (understate) the

taxes on intermediate use and understate (overstate) the taxes on final use whenever the tax falls on only some of several aggregated commodities, and the commodities burdened with the tax are only in final (intermediate) use whereas the aggregate is used at both ends.

Two measures would eliminate the entire discrepancies with the input-output tables. The first is to substitute Statistics Canada large aggregation data tapes for published medium aggregation tables. The second is to explicitly model the excluded final demands for primary factors, the uses of non-competing and unallocated imports, and the production of unallocated exports. The first measure would entail calibrations on a main-frame computer that defeat some of the purposes of making a micro-computer model. The second may, for now, be left as one of the suggestions for further research.

5 AGGREGATION

The model uses data on the factor employment and output of 43 industries, the income and expenditure of 10 households, and the use of 92 commodities by industries and households. It may not always be desirable to carry so much detail and when it is not, industries and households can be aggregated to smaller numbers. In every case, the demands for the 92 commodities must be converted into demands on the smaller number of industries that is retained. This conversion results in a squaring of the commodity by industry matrices. Because of the constant term in the linear personal income tax function, household aggregation must preserve equality in the number of households per class. The number of households must therefore be a factor of 10, that is either 1, 2, 5, or 10. Apart from this, household aggregation presents no further problems. Industry aggregation, however, can pose a problem, which is that certain simulations can be highly dependent on it, as is illustrated in the last chapter. The simulated effect of a tax policy will depend on aggregation whenever a policy effect can be said to depend on whether an industry is capital or labour-intensive, a net exporter or importer, or a producer of an important intermediate input.

A labour-intensive industry is one that employs more "men per machine" than other industries faced with the same factor prices,

at all factor prices. If a policy effect depends on such a characteristic, the simulated effect of the policy can change significantly if a labour-intensive industry was aggregated with a capital-intensive one. Aggregation amounts to re-writing model equations by inserting different parameter values. In this case, the parameter that changes is the labour-share parameter (delta) in the production function. The model chooses a value of delta that fits the input-output table data on factor use, given the modelers' assumptions about factor substitution elasticities. Aggregation changes the proportions in which factors are seen to be employed, and therefore labour-share parameters change even when the same elasticities are assumed. The effect of a trade policy will depend on whether the output of some industry is primarily exported or competes with imports. Simulation results should be expected to change if an industry that is a net exporter is aggregated with one that is a net importer.

Finally, the linear input-output relationships in the model can be accused of much mischief. These inter-industry relations can be represented by straight lines that are shifted about by aggregation. A simple model solution can be visualized as the point where two lines cross, but the point where two straight lines cross after one or both of them are shifted by aggregation can be very far from their initial intersection. While the exact description of what happens after aggregation is too complicated to be given here, the above may suffice to give the flavour of the amount of mischief that can be created by the linear functions in

the model. The following paragraphs provide more technical detail of the operations carried out on the data during aggregation and matrix squaring.

Aggregation of industries is made by addition of industry columns in the make and use matrices, and in the taxes matrix.

Aggregation of households is made by addition of household columns in matrices of final demands by household and household endowments. Original household survey data are grouped in deciles ranked by income. Household aggregation preserves the equality of the number of households across groups.

The following additional tasks are performed prior to industry aggregation:

1. Unincorporated "business" income generated in the owner-occupied housing "industry" is added to the industry's "other operating surplus."

2. Unincorporated business income in the remaining industries is distributed over labour income and other operating surplus at a 2:1 ratio.

3. Property tax payments by industry are calculated, deducted from indirect taxes and saved in a separate row.

Non-commodity taxes paid by owner-occupied housing are treated as if they all were property taxes. Their amount is deducted from total property tax collections per National Accounts. The result of this subtraction is divided by the sum of non-commodity taxes paid by industries other than owner-occupied housing. This ratio is then used to estimate property taxes paid by industry. These are then subtracted from indirect taxes and saved in their separate row.

4. Royalty payments are deducted from the Finance, Insurance and Real Estate row of the Use Matrix.

5. The supplementary labour income and wages and salaries rows of the use matrix are added together.

6. An effective sales tax rate by expenditure category is obtained from the final demand matrix dividing the indirect tax row by the column sums.

7. Rates of sales tax by commodity are obtained dividing the margins column by the sum of intermediate use and final private expenditure (the sum of columns 1-24 in Final Demand). The rates are multiplied by intermediate and final expenditures to obtain the revenues from taxation of final and intermediate transactions. The revenues from taxes on inputs are aggregated. They are then saved in n+1 margin columns together with the revenues from taxes on final sales.

8. Family expenditures by category derived from the Family Expenditure Survey are scaled up (or down) to equal final demands by consumer expenditure category, published in Input-Output tables. The result is the FAMEX matrix.

9. The Final Demand matrix is converted to a Demand Shares matrix dividing each element by its column total.

10. A matrix F of consumption expenditure by consumer and by commodity is obtained by matrix multiplication.

    F = [Demand Shares] [FAMEX]

11. Fixed Capital Formation and Net Inventory Change are distributed over households in proportion to each household's share in their total net worth. The result is investment expenditure by household and by commodity and is added to F. The sum is the Demand matrix of expenditure by consumer and commodity.

12. Labour endowments of households are estimated as equal to labour income that could have been earned if all adults in the household had worked 52 weeks without any change in their average weekly earnings.

13. Leisure is set equal to labour endowment of the household less its earnings.

14. Rates of commodity taxes on final demands by residents (columns 1-23 in the FD table) are scaled up to yield the revenues in the indirect tax row of the same table.

The Treatment of Sales Taxes on and Imports for Intermediate Use

Commodity tax rates and intermediate import requirements are calculated before industry aggregation.

When the calculations are done before aggregation, tax rates and import ratios are seen after aggregation to vary across industries along a commodity row. This variance could not be brought out if the computations were made after aggregation. This method would ideally be applied at the large aggregation level but, for the time being, it is done at the medium level.

5.1 Squaring

The model uses square input-output matrices whereas the Canadian input-output system is rectangular.

The rectangular matrices are squared by multiplication with a market share matrix.

The market share matrix is obtained by first transposing the Make Matrix so that industries are in the rows, commodities in the

columns. Each row is then divided by the column sum. The result is MS, the Market Shares. Any rectangular matrix R can then be converted to a "square" S by

$$S = [MS]\ [R]$$

The matrices to square are Use, Final Demand, Margin, Export tax, Duty and Demand. An intermediate import demand matrix also has to be squared.

6 CALIBRATION

Model parameters are not estimated econometrically but by a more primitive procedure known as "calibration." Many model equations have free parameters that can be adjusted so that the equations will fit the data, given assumptions about the remaining parameters. This adjustment of parameters to make the model fit the data is what is called calibration. The parameters found by calibration were listed in section 2.3. A further aspect of the calibration process is the rescaling of data drawn from mutually inconsistent sources so that they add up to common control totals.

A fundamental assumption underlying the calibration process is that of "equilibrium." There are two aspects to this notion of equilibrium. The notion refers to a state of affairs resulting from behaviour under constraint. The behavioural assumption is that certain things are maximized (e.g., profits) and others minimized (costs), subject to constraints imposed by factor endowments, prices, and taxes, to name only the economic constraints. These can be expressed in accounting identities that must be met in calibration. The accounts must balance exactly, as they also do in the national input-output tables. It is to achieve this result that some data are rescaled during calibration.

The difficulty is with the behavioural assumptions that impute purposes to the particular ways in which the accounting identities are met. These assumptions enter at three levels: first by assuming some maximizing or minimizing behaviour, secondly by imposing functional forms on the objectives and lastly by introduction of particular parameter values. All three interplay with accounting identities to determine the free parameters. Different assumptions could, of course, be substituted to yield other parameter calibrations and even other models. The choices made here follow common procedures in the general equilibrium field, except for -- perhaps -- the treatment of two-way trade.

The calibration proceeds in two stages. In the first (pre-calibration) one obtains variable values, tax rates and other ratios readily derivable from the data without explicit elasticity assumptions. Second, elasticity assumptions are introduced together with a few data not yet on file to complete the parameter calibration. These are described in detail in the next two sections.

6.1 Pre-Calibration

Pre-calibration is the computation of expenditure and tax parameters that can be obtained from the squared matrices on file, without further input of data or elasticity assumptions.

The following items are computed:

1. Gross domestic product (from Final Demand).

2. Total revenue from indirect taxes and from factor taxes (corporate income, property and payrolls).

3. Foreign trade balance.

4. Imports less re-exports.

5. Net government purchases of goods and services (less sales).

6. Ratios of imports for final use to final demand by residents (μ).

7. Rates of tax on final sales, intermediate sales, corporate income, property (relative to net of tax capital income), payrolls, imports, exports.

8. Rates of other commodity taxes less subsidies, by industry.

9. Royalty rates (ad-valorem on industry output).

10. Total capital income.

11. Total labour income.

12. Labour and capital incomes by household:

    - Capital income: distributing the total in proportion to net worth.

    - Labour income: scaling earnings so they add up to the total.

The following adjustments are made:

13. Labour endowments and leisure by household are rescaled according to the new labour-income total.

14. Zeroes are substituted for negative cells in the matrix of expenditures by households and government (negative values arise by withdrawals from inventory and by government sales. They are more frequent in more disaggregated models or when recession year data are used.)

15. Expenditures are rescaled so that totals are preserved after elimination of negative entries.

    These are the only adjustments that cause a deviation of the model's data from published input-output tables.

Computations continue:

16. Disposable incomes of households and government are obtained by adding up their respective expenditures. Sales taxes are included in the case of households.

17. GNE is obtained as the sum of household and government expenditures.

18. GDP is recomputed as the sum of value-added by primary factors plus royalties and indirect taxes. The difference from GDP found in Step 1 is stored. It arises from omission of non-competing imports, unallocated imports and exports, and final demands for the services of primary factors. Omission of these items from the model amounts to a shift in the origin of the economy's production possibilities. A measure of this shift is saved for later additions to GDP and GNP computed in simulations.

19. An open model Impact (Inverse) Table is computed.

20. GDP less the trade surplus is compared to GNE for a final accounting check.

6.2 Calibration

Elasticity assumptions are required to complete the calibration. Some elasticity assumptions can be obtained by literature search. Other parameters can be chosen by experimenting with the calibration. Finally, one can make slight amendments to the received data.

The first items required are the slope in the linear personal-income tax function and the personal income-tax revenue. Family Expenditure and Survey of Consumer Finances data suggest a figure of about .2 (20 per cent). Given this, the constant in the linear personal income-tax function is adjusted so that, when the function is applied to household incomes, one obtains the actual (federal and provincial) revenue from personal income taxes. The absolute size of the constant is directly proportional to the number of household classes retained after aggregation.

Next, one requires a summary figure for the country's net international investment income position. The default position is that net foreign investment income equals the commodity trade deficit. If this is accepted, the foreign trade accounts balance as published. An alternative is to say that earnings retained and reinvested by non-residents should be shown explicitly in the capital and current accounts. If this position is taken, one might set the capital income of non-residents at a figure higher

than the trade balance. Canada's withholding tax revenue is also entered at this time.

If the trade accounts are modified by adoption of the second position above, then the calibration produces a balancing entry called "exogenous government imports" (foreign aid, service of the foreign debt, diplomatic and consular expenditures, etc.). Whichever choice is made, household capital endowments and capital incomes are reduced, scaling them down proportionately so that they add up to capital income of residents.

Income and withholding taxes are added to the tax revenue obtained in precalibration. Total transfers equal tax revenue less government imports. Transfers to households equal disposable incomes less after-tax factor incomes. Transfer payment shares can now be computed.

Next, assumptions have to be made about the rental price of capital abroad and the elasticity parameter in the foreign capital supply function. A supply elasticity is then computed and displayed. If the value of the displayed elasticity is unsatisfactory, the input to it can be changed until a satisfactory result is achieved. Other input is more straightforward. It consists of export demand elasticities and of elasticities of substitution in production and in consumption. In place of the latter, one can substitute uncompensated price elasticities of demand by each household and by government for

one of the goods and services in the model. Given demand elasticities, the program computes substitution elasticities consistent with expenditure data and price elasticities.

The α's, γ's, σ's, δ's, and ϕ's in utility and production functions are derived form marginal conditions and substitution elasticity assumptions. Shift parameters in the foreign capital supply and export demand functions are derived form elasticity assumptions and data on the corresponding flows. Throughout, units are conventionally defined to be such that base case prices are one dollar per unit. Duty-paid import prices are also equal to one and therefore world market prices are generally less than one.

Finally, the base case utility levels of households and government are computed and saved for welfare comparisons after simulation.

The result of this calibration is a file of function parameters, exogenous variable values, and tax rates. Running this through the model solution without policy change reproduces the original data without iteration.

7 POLICY CHANGES

The solution menu consists of eleven tax policy changes. The taxes that can be changed are:

corporate income
property
payroll
royalties
final sales
intermediate sales
other commodity taxes
import duties
export levies
personal income
non-resident withholding.

The tax rates can be changed either by entering a new value or a percentage change in the rate. In this last case, the new value of the tax rate is computed.

A GNP-type value-added tax is offered as an alternative to changes in sales taxes on intermediate products.

The disposition of tax revenue can also be changed by entering new transfer payment shares. Since government is modelled as a transfer recipient, changes in transfer shares can be used to simulate a change in government expenditures and also to hold constant the utility of government expenditures.

Appendix B shows results from an experiment where the only policy change was the elimination of export levies.

8 SOLUTION

The solution process consists of two parts: in the first -- the solution set-up -- one determines the type of solution that is to be reached. In the second, the algorithm takes over to find the solution.

In every simulation, the behavioural assumptions and objectives, and most of the constraints built into the model are maintained. Certain constraints had been modified by changing policy parameters but other constraints are still open and can be left so or applied. The time to do so is during solution set-up. At this time also the solution might be accelerated by guessing the factor allocations and factor prices that it might entail.

8.1 Solution Set-Up

There are a number of prompts to answer and choices to make before a model is solved.

A description of the simulation experiment is entered. This and the date are later stamped on every output screen and paper copy.

Next, there are three choices to make:

- whether the solution will start from the previous equilibrium or not;
- whether total tax revenue is to be held at its base case level or not; and
- whether government utility is to be held constant or not.

Guesses have to be made unless the previous equilibrium is chosen as the starting point.

If tax revenue is to be held constant, a further choice must be made from a menu of active (non-zero) taxes and subsidies available for adjustment to the revenue requirements.

An elasticity of substitution of foreign for Canadian products in final demand is also entered at this point. Finally, the order of some equations can be changed by throwing a switch into one of four positions.

8.2 Solution Algorithm

The solution algorithm is a variation on the Gauss-Seidel method. Instead of iterating over the entire equation system, the algorithm iterates over a small sub-set of equations. When a sub-set is solved, it is expanded by bringing additional equations into it. This is continued until finally all equations are in the set and solved simultaneously. One equation, however, is always

left out. This is an equation that can be omitted by Walras' Law. It is used after the output is printed to check the accuracy of the solution or the adequacy of the user-chosen tolerance level.

What this solution method really amounts to is a substitution of economics for mathematics in the solution of an economic model. The solution of the first sub-set of equations is equivalent to the solution of a partial equilibrium problem. This is then successively expanded towards a general equilibrium. Thus one might call this a "Marshall-Walras" algorithm.

This algorithm has at least three advantages over others currently in use to solve general equilibrium models. First, it needs fewer guesses to start, since one only needs to guess the values of the few variables in the first sub-set. This is a small advantage because usually one can use previous equilibrium values as initial guesses. It is a rare case where one would explicitly have to enter guesses. Greater advantage stems from solving simple, short equations that are essentially partial equilibrium equations. No long, tedious, and hazardous substitutions have to be made. The third and largest advantage is flexibility. When the solution consists of short and simple partial equilibria, it is surprisingly easy to change the model structure by rewriting, deleting, or inserting equations.

The difficult part is to find the order in which the solution can be expanded from partial to general. In a static model where

factor endowments are given, it seems most practical to start with the allocation of factors to industries, or with a partial equilibrium in the factor markets. When this is achieved, outputs and product prices can be computed. Given export and import demands, the partial equilibrium can be made to encompass the foreign sector.

When factor markets and the foreign trade are in equilibrium one can compute personal incomes and government tax revenue. Given these, the system can grow to include final demands and supplies. If these are not in equilibrium, the initial factor allocations are revised.

The solution process is speeded up by successive reductions of the error-tolerance level. Iterations start with a tolerance greater than that specified by the user. This is then reduced each time the full system meets the temporary tolerance criterion, until the specified level is passed. With a floating-point math co-processor in an IBM-PC, a typical simulation of a 42-industry model solves in 90 seconds. A small aggregation model with 466 equations is solved in 25 seconds. A smaller, 60-equation model is solved in 5 seconds. Quicker solutions are attainable with other available micro-computers.

9 TAX SIMULATIONS

In this Chapter I present the results of some tax policy simulations that illustrate features of the model, namely its terms-of-trade effects, alternative treatments of government expenditures, and the importance of having a flexible aggregation routine.

The Base Case is the 1980 Canadian economy. The simulation cases are three: a value-added tax (VAT), a "uniform tax", and a VAT superimposed on the latter. First, I simulate a "uniform tax rate system" characterized by uniformity of tax rates across industries while retaining differences in tax rates across different tax bases. For instance, the corporate income tax rate is set at the same level on all industries, and so is the property tax rate, but the former does not equal the latter. This is one way to set broadly based taxes and to avoid many tax distortions without unduly affecting the revenues of different levels of government. Tax rates are equalized by setting them at the level of their average across all industries. Thus municipalities would continue to collect property tax at the average rate and the federal and provincial governments continue to collect corporate income tax at its average rate. The average rates in question are:

Corporate income	.14045
Payrolls	.03778

Property	.117012
Royalties	.0105324
Sales, final	.0514265
Intermediate	.0195323
Other commodity taxes	-0.0062143
Import duties	.040493
Export levies	.0109015

Expansion and contraction of tax bases may change tax collections by source and total tax revenue of all government levels. This total is adjusted by small changes in the marginal personal income tax rate.

It might take some stretch of the imagination to regard this uniform tax rate case as an example of a feasible tax reform. Indeed, it is not meant to be a realistic case but only a benchmark case illustrating the well-known theoretical principle that the economic cost of any tax stems more from its variance than from its level.

One should never put too much stock in the realism of an economic simulation, but for those uninterested in unrealistic simulations there are a number of defences of this first case. Here we might just make one, possibly the most difficult one. Consider the case of owner-occupied housing, which is one of the "industries" in the model. One might ask how there could ever be

a corporate income tax on the "profits" generated by owner-occupied housing or a sales tax on the services provided by it. It goes without saying that neither of these two taxes could be imposed on housing and in their traditional form. However, in the context of this model, it is possible to impose the equivalent of such taxes on housing and, in fact, this equivalent tax is already in place. In this model (as in the Canadian input-output tables) owner-occupied housing does not employ labour. Its "output" is a function of only the input of capital plus the value of some intermediate inputs in fixed proportions to capital. Thus a tax on the employment of capital, such as a profits or property tax, cannot distort input choices (there is no capital/labour ratio to distort) and is equivalent to a sales tax. Any tax on housing or inputs to housing simply raises the cost of homeownership. But if profits, property, and sales taxes on housing are equivalent, the equivalent to any one of them can be imposed by varying the traditional property tax rate. Imposition of the equivalent of a uniform tax on income, property and sales of the owner-occupied housing industry would actually mean a 25 per cent reduction in taxes on housing. The resulting changes in revenues by different levels of government can be reversed by inter-governmental transfers without further consequence in the context of this model. The above should remove one of the difficulties of visualizing the uniform tax rate case. Simpler arguments are available to lessen the extent of other conceptual difficulties with this case. The real difficulties with this case

are, first that it involves a levelling of sales taxes on alcohol, tobacco and gasoline and a reversal in their trend; and secondly, that it implies a sharp increase in taxes on government enterprises included among the various industries.

In Case 1, I am retaining separate sales taxes on domestic consumption (supplied by domestic industry and imports) and on inputs to domestic production to meet both domestic consumption and foreign export demands. Thus, input taxes contain an element of hidden export tax additional to the explicit export levies. This bias against exports is one of the criticisms levied at Canada's federal Manufacturer's Sales Tax (MST). This and some of the other alleged defects of the MST are removed in Cases 2 and 3 with the simulation of a GNP-type value added tax (VAT).

The VAT is of the GNP-type because in a static model there is no distinction between consumption and investment expenditures. There can also be no question of depreciation and this is not deducted from income.

In a static model, a consumption-type VAT might actually look worse than a GNP-type VAT. Exemption of investment goods would give the appearance of variance in taxes on arguments in utility functions and the model would compute a welfare loss as the result of this variance. From the point of view of a dynamic model, this variance and the resulting welfare loss would be misleading. In

such a model, purchases of investment goods would not contribute to current period utility. Future consumption goods would enter into the utility functions instead and, if they are taxed at the same rates as current consumption, there would be no variance in taxes on consumption precisely because of the exemption of investment goods.

These distinctions between present and future escape static models. The focus is therefore not on questions about income and consumption taxes, but on turnover versus value-added and retail sales taxes. An historical example of a GNP-type VAT is the Michigan Business Activities Tax as imposed from its inception up to 1955, when it was amended to allow deduction from the tax base of real property depreciation.

In Case 2 the VAT is imposed on top of the "uniform taxes". Input taxes are eliminated and the rate of tax on final sales to residents is set equal to the sum of the average of the erstwhile sales-tax rates, namely .0709588. The personal income tax rate is allowed to increase to hold total, real government revenue at its base case level.

In Case 3 the same VAT is imposed on the existing tax system without first reducing the variance in tax rates across industries. The only tax rate that does not vary by industry is the VAT rate.

Each case was run six times: at three different levels of aggregation and under two different assumptions about government expenditures. In every case, money prices are normalized on GNP and the deflated amount of total tax revenue is held constant. There are no simulations of an aggregate tax increase or decrease. However, revenue-neutrality is an ambiguous concept. It is so because the price index used by the private sector to tally its real tax burden is not the same as the index of the prices of things purchased by government. The general price index may remain constant while relative prices move against or in favour of government purchases. Consequently, I alternatively do and do not hold constant the utility of government purchases, which is the real level of government expenditure. In the former case, revenue-neutrality is imposed in terms of real government expenditure. This process may require an increase in the households' shares in transfer payments and a corresponding reduction of the proportion of tax revenue spent by the government.

Finally, the simulations were made with 3-, 16- and 42-industry aggregations. The reason I stopped one short of 43 industries is that, in 1980, Petroleum and Coal Products (industry 25) had paid more corporate income tax (on the industry basis) than its total capital income, including interest paid and capital consumption (other operating surplus at the establishment level). The implied negative employment of capital creates havoc in the mathematics of the model. To avoid this, I aggregated Petroleum and Coal with

Mining and Mineral Fuels. (Such are the consequences of gathering data at the firm and establishment levels of vertically integrated industries.)

The 3-industry model also has only two households ("poor" and "rich") while the 16- and 42-industry models retain ten households divided into deciles.

9.1 Calibration Assumptions

Elasticity assumptions for calibration were made so as to facilitate the comparison of aggregated with disaggregated models.

	Primary Industries	Secondary Industries	Service Industries
Elasticity of capital/ labour substitution	.7	1.1	1.4
Foreign price elasticity of export demand	-3.0	-2.5	-1.0

	Elasticities of substitution in consumption	
	Goods	Leisure
Low income households	.9	.1
High income households	1.1	.1
Government	.75	n.a.

Foreign capital supply elasticity: 4.2

The export demand elasticities average out to a figure between those obtained by Burgess (2.0 to 2.5) and Appelbaum and Kohli (3.6). The foreign capital supply elasticity lies between the values obtained by Hood, Glenday and Evans (2.5) and D. M. Leipziger (7.0). The import-content of final demand is assumed to have zero elasticity with respect to the ratio of Canadian to foreign prices. The elasticities of substitution of goods for leisure imply very low elasticities of labour supply such as those recently found by Eden Cloutier.

The same assumptions are used at all levels of aggregation. For example, the seven primary industries in the 42-industry model are all assumed to have the same .7 elasticity of capital/labour substitution. Differences between models are thus due more to disaggregation of data and to tax variance than to variance in behavioral assumptions.

9.2 Results

Tables 1, 2, and 3 show the results in 3-industry, 2-household, 16-industry, 10-household, and in 42 by ten models. The results are accurate to within one-millionth. The first result to note is the effect of disaggregation. The economic gain from a tax change appears to be significantly larger when the economy is disaggregated from 3 to 16 industries. The well-known theoretical reason for this is that welfare gains depend on the squares of

Table 1

3-industry, 1980, Tax Simulations

	Case 1		Case 2		Case 3	
	Uniform tax rates		GNP-type VAT on top of uniform rates		GNP-type VAT on top of distorted system	
	(percentage change from Base Case)					
Real Wage	-.44	(-.43)	-.05	(-.04)	.47	(.47)
Rental Rate of Capital	1.23	(1.25)	1.30	(1.32)	.42	(.42)
Exchange Rate	-.11	(-.10)	-1.29	(-1.25)	.39	(.38)
Foreign Capital Employed	6.96	(6.96)	12.28	(12.28)	.56	(.56)
Labour Supply	-.04	(-.06)	.03	(0)	.15	(.16)
	(millions of dollars)					
Economic Gains by Households						
Lower-income half	-9	(94)	-152	(22)	-398	(-445)
Upper-income half	158	(146)	-163	(-182)	-591	(-586)
Government	97	(0)	166	(0)	-44	(0)
Total	247	(241)	-149	(-160)	-1,034	(-1,031)
	(percentage change)					
Marginal Personal Income Tax Rate	.14	(.11)	1.6	(1.5)	2.4	(2.4)

Note: Figures in parentheses are the results of holding constant the utility of government expenditure.

Figures may not add up due to rounding.

Table 2

16-industry, 1980, Tax Simulations

	Case 1		Case 2		Case 3	
	Uniform tax rates		GNP-type VAT on top of uniform rates		GNP-type VAT on top of distorted system	
	(percentage change from Base Case)					
Real Wage	-.66	(-.66)	-.25	(-.26)	.24	(.24)
Rental Rate of Capital	2.08	(2.11)	2.03	(2.09)	.65	(.67)
Exchange Rate	.30	(.34)	-.91	(-.84)	1.84	(1.85)
Foreign Capital Employed	9.51	(9.53)	14.45	(14.49)	-4.5	(-4.5)
Labour Supply	-.19	(-.22)	-.08	(-.14)	.30	(.29)
	(millions of dollars)					
Economic Gains by Households						
Lowest decile	38	(63)	12	(57)	-94	(-85)
2nd decile	71	(107)	35	(100)	-100	(-87)
3rd decile	98	(139)	52	(125)	-118	(-104)
4th decile	92	(126)	38	(99)	-138	(-125)
5th decile	80	(105)	19	(65)	-163	(-154)
6th decile	90	(109)	23	(55)	-185	(-178)
7th decile	92	(105)	18	(40)	-203	(-199)
8th decile	84	(88)	0	(6)	-250	(-248)
9th decile	88	(80)	-8	(-22)	-296	(-299)
10th decile	278	(237)	131	(58)	-522	(-537)
Government	157	(0)	280	(0)	57	(0)
Total	1,169	(1,158)	600	(582)	-2,012	(-2,016)
	(percentage change)					
Marginal Personal Income Tax Rate	.36	(.31)	1.8	(1.75)	2.4	(2.38)

Note: Figures in parentheses are the results of holding constant the utility of government expenditure.

Figures may not add up due to rounding.

Table 3

42-industry, 1980, Tax Simulations

	Case 1		Case 2		Case 3	
	Uniform tax rates		GNP-type VAT on top of uniform rates		GNP-type VAT on top of distorted system	
	(percentage change from Base Case)					
Real Wage	-.08	(-.08)	.38	(.38)	.38	(.38)
Rental Rate of Capital	1.20	(1.22)	1.21	(1.24)	.87	(.87)
Exchange Rate	2.68	(2.70)	1.28	(1.33)	.98	(.99)
Foreign Capital Employed	-5.2	(-5.1)	.77	(.79)	.27	(.27)
Labour Supply	-0.14	(-.16)	-0.04	(-.07)	.07	(.07)
	(millions of dollars)					
Economic Gains by Households						
Lowest decile	5	(21)	-18	(13)	-26	(-2)
2nd decile	35	(58)	1	(47)	2	(5)
3rd decile	48	(74)	5	(57)	-0	(3)
4th decile	74	(96)	25	(68)	7	(9)
5th decile	90	(105)	33	(65)	-6	(-4)
6th decile	131	(141)	68	(90)	5	(6)
7th decile	146	(153)	78	(92)	3	(4)
8th decile	137	(137)	56	(59)	-6	(-56)
9th decile	129	(123)	38	(25)	-10	(-97)
10th decile	-27	(-55)	-187	(-243)	-521	(-524)
Government	93	(0)	186	(0)	12	(0)
Total	861	(852)	285	(274)	-678	(-679)
	(percentage change)					
Marginal Personal Income Tax Rate	.92	(.90)	2.6	(2.56)	2.46	(2.45)

Note: Figures in parentheses are the results of holding constant the utility of government expenditure.

Figures may not add up due to rounding.

deviations of tax rates from their average level. Such deviations can, however, only be brought to light by disaggregation.

Further disaggregation to 42 industries does not add to welfare cost measures but affects factor prices and the exchange rate.

The 42-industry model appears to be less sensitive to tax changes than the 16-industry model. One reason for this is that the 42-industry tax system looks rather different from the tax system imposed on the 16-industry model. This is illustrated by the simple correlations in Table 4. The observations are the industries and the variables are the tax rates on profits, labour, property, resource royalties, final sales, other non-commodity taxes, import duties and export levies, in that order (sales taxes on intermediate transactions were excluded for lack of degrees of freedom). While these simple correlations are seldom significant, it is their size and sign that matters in model simulations.

They are generally smaller at the 42-industry level and show six sign changes among 28 coefficients below the diagonal. Changing the level of aggregation can thus be like simulating a different economy.

The next result is a lesson in second-best policy: that the Case 3 VAT without further tax reform is a bad proposition. While it may be an improvement if considered in isolation, a VAT

Table 4

Simple Correlations Between Tax Rates, 1980

42 Industries

	1	2	3	4	5	6	7
1	1						
2	.42	1					
3	.12	-.14	1				
4	-.005	.03	-.02	1			
5	.16	.24	-.11	.02	1		
6	-.10	-.21	-.06	-.50	-.18	1	
7	.27	.44	-.15	-.22	.43	-.03	1
8	.03	.10	-.09	-.03	-.07	-.02	.37

16 Industries

	1	2	3	4	5	6	7
1	1						
2	.61	1					
3	.12	.48	1				
4	.09	.16	-.02	1			
5	.45	.32	-.03	-.11	1		
6	-.15	-.32	-.08	.06	-.47	1	
7	.67	.35	.014	-.20	.86	-.53	1
8	.13	.22	-.09	.83	-.004	.06	-.095

applied at a uniform rate serves mostly to highlight the remaining tax variances. Some of these might have been offset by the ancient sales taxes and could make their full negative economic impact on the introduction of a uniform, non-offsetting VAT.

Disaggregation picks up not only the "Harberger triangles" caused by tax variance but also the associated rectangles of welfare gain created when a tax shifts economic activity over to already taxed sectors. The balance of rectangles and triangles is changed significantly by disaggregation as suggested by the simple tax-rate correlations.

In the 42-industry case, the straight VAT affects almost exclusively the highest income group. One reason for this is that this group alone purchases about one-third of the output of the construction industry and, under a GNP-type VAT, would pay VAT on new construction at a higher rate than the current one on inputs to new construction.

Third, government is the main beneficiary of a VAT unless its real expenditures are expressly held constant. This result is even stronger when the VAT rate is increased to prevent the rise in the personal income tax rate. The simple reason for this is that government was modeled as exempt from retail sales taxes and VAT but still paid hidden input taxes in the base case. A VAT removes these taxes so that the same dollars of government revenue

can buy a larger bundle of private sector products. Whether government expenditure is held constant or not shows up mainly in transfers to households but also in the wage rate relative to the cost of capital. The effect on the wage rate stems from the labour-intensity of government purchases.

Fourth, comparison of a VAT with the Base Case shows an effect on the exchange rate frequently omitted in discussion of the alleged MST penalty on exports and inducement to import. To the extent that this bias against net exports exists, the MST should depress the exchange value of the Canadian dollar. The model sometimes confirms this. The effect on the dollar can serve to offset the bias in the sales tax. This is seen most clearly in the 3-industry model (Table 5).

The VAT raises export quantities by 4 per cent. The additional exports push Canadian export prices down by one cent and foreign currency prices by a little more than one cent. Given fixed world prices of imports, our terms-of-trade turn against us by that one cent. This is a source of a significant welfare loss when multiplied by billions of dollars' worth of exports.

The expected appreciation of the Canadian dollar following the imposition of a VAT appears more clearly in Case 2. In Case 3 it materializes only in relation to wages and capital incomes which rise relative to the price of foreign currency. The losses from

Table 5

Effects of MST and VAT on Canadian Trade, 1980

	Industries		
	Primary	Secondary	Services and Margins
Net Exports			
Base Case	5.0	- 7.6	4.7
Case 3	5.4	- 6.9	5.0
Producer Prices			
Base Case	1.0	1.0	1.0
Case 3	.99	.98	.99
Exchange Rate			
Base Case	1.0		
Case 3	1.004		

deterioration in Canada's terms of trade are shown in Table 6. They represent gains to the rest of the world.

The effect of a VAT on the exchange rate in disaggregated models is contrary to the expected one. One reason for this can be that a VAT encourages, and the existing sales taxes discourage exports that have particularly high import requirements. This puzzle requires further investigation.

Finally, the GNP-type VAT is somewhat progressive. When it creates a loss, the loss is concentrated in the upper income ranges. When it yields a gain, the gains are concentrated in the middle to lower income ranges. The two main reasons for this are, first, that the VAT base includes investment goods and depreciation; second, government either gains or transfers its gain to households in proportion to their base case transfer receipts. This tends to favour the poor. A small revenue shortfall is made up by higher personal taxes paid mainly by higher income households.

Table 6

Losses due to terms of trade deterioration.

	Case 1 uniform taxes	Case 2 VAT on uniform taxes	Case 3 VAT only
	(in millions of dollars and per cent of GNP)		
3-industry model			
EV	630 (0.21%)	1,222 (0.4%)	1,458 (0.49%)
CV	190 (0.06%)	810 (0.27%)	1,400 (0.47%)
16-industry model			
EV	1,796 (0.6%)	2,552 (0.86%)	2,596 (0.87%)
CV	-132 (-0.04%)	714 (0.24%)	2.443 (0.82%)
42-industry model			
EV	1,503 (0.5%)	2,384 (0.8%)	2,091 (0.7%)
CV	614 (0.21%)	1,401 (0.47%)	1,977 (0.67%)

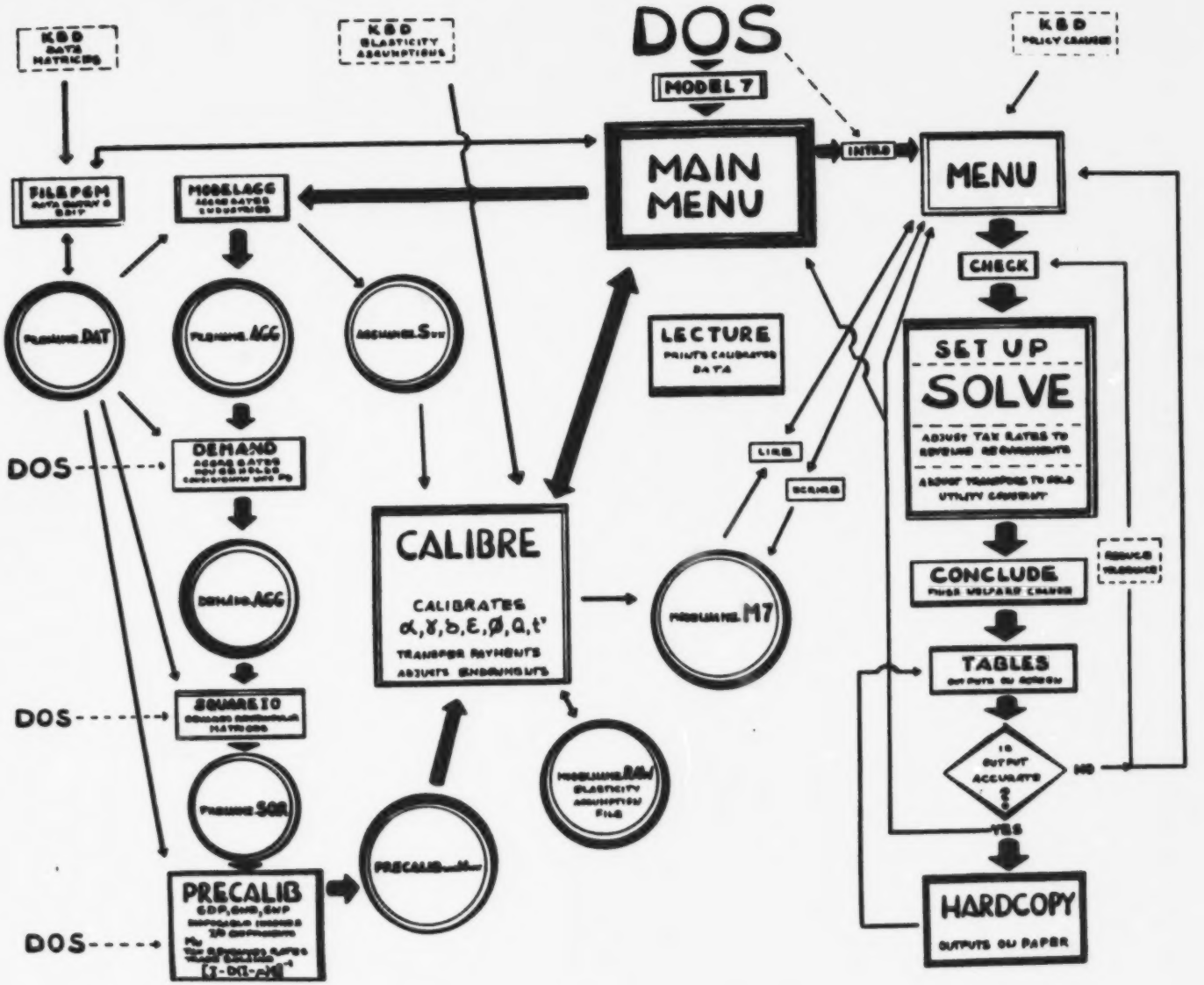
EV: New exports less new imports evaluated at old prices.
CV: Old imports less old exports evaluated at new prices.

APPENDIX A

The two illustrations in this appendix show the structure of programs and files for data storage, model aggregation, calibration and model solution.

The first diagram is a program flowchart. Rectangles indicate computer programs; circles depict diskette data files. Arrows show the direction in which the work can flow. The work starts by using the FILEPGM on the upper left corner to create files that are later fed into the aggregation and calibration process. These files -- ending with the name extension .DAT -- contain data copied from original sources. The data are arranged in these files by rows and columns according to the scheme shown in the second diagram.

Once the data are on file, the work proceeds in a sort of figure 8, starting from the main menu towards the left, through aggregation and calibration, then back to the main menu and over to the policy menu on the right side. This right side is the one most used, aggregation and calibration being the rather less frequent jobs. The whole process can be run through in less than ten minutes.


KBD
DATA MATRICES
KBD
ELASTICITY ASSUMPTIONS
DOS
MODEL 7
KBD
POLICY CHANGES
MAIN MENU
INTRO
MENU
FILEPGM
MODELAGG
CHECK
LECTURE
PRINTS CALIBRATED DATA
SET UP
SOLVE
ADJUST TAX RATES TO REVENUE REQUIREMENTS
ADJUST TRANSFERS TO SOLVE UTILITY CONSTRAINT
DOS
DEMAND
LIMB
SCRIMB
CALIBRE
CALIBRATES
α, γ, b, E, β, Q, t'
TRANSFER PAYMENTS
ADJUSTS ENDOWMENTS
CONCLUDE
REDUCE TOLERANCE
TABLES
DOS
SQUARE10
IS OUTPUT ACCURATE ?
NO
YES
DOS
PRECALIB
HARDCOPY
OUTPUTS ON PAPER

92 COMMODITIES
43 INDUSTRIES
MAKE
43 INDUSTRIES
USE
29 CATEGORIES
14 CONSUMPTION CATEGORIES
10 INVESTMENT CATEGORIES
FINAL DEMAND
EXPORTS & IMPORTS
GOVERNMENT PURCHASES
INDIRECT TAXES
DUTY
EXTAX
MARGIN
USE
TAXES
10 HOUSEHOLDS
FAMEX
ENDOW
4 ENDOWMENTS
14 CONSUMPTION CATEGORIES

MODEL 7 by S. Dahus (c) 1986, Economic Council of Canada.

INPUT, OUTPUT AND TRADE

INDUSTRY	CAPITAL INPUT	LABOR INPUT	GROSS OUTPUT	INTERMEDIATE DEMAND	FINAL DEMAND	IMPORTS	EXPORTS
			(In billions of dollars)				
Agriculture	5.199505	3.505483	16.260073	11.042314	1.772795	1.371879	4.816843
Forestry	0.406000	1.533455	4.672302	4.474549	0.172366	0.102554	0.127941
Fish. Hunt. & Trap.	0.221529	0.347664	0.834411	0.749441	0.022298	0.133987	0.196660
Mining	12.199035	4.454334	33.373341	28.433588	2.031947	11.808784	14.716589
Manufacturing	13.234087	36.304741	175.669891	107.120949	76.997391	56.956020	48.507568
Construction	4.513621	14.732216	49.655762	7.496643	42.164349	0.008527	0.003297
Transport	3.090241	9.387192	24.794664	18.135654	5.489837	0.861913	2.031086
Communication	2.547700	4.577600	9.648123	5.774180	4.048960	0.403401	0.228385
Utilities	5.544661	2.138580	9.960068	4.692522	4.483656	0.024969	0.808859
Wholesale Trade	2.431193	9.453713	19.817553	9.745750	8.339792	0.644431	2.376441
Retail Trade	3.268853	12.634298	24.938168	3.875497	21.064049	0.090361	0.088982
F.I.R.E.	22.997585	11.237402	57.415657	14.622861	43.664272	1.192507	0.321030
Services	6.312590	18.069944	39.527405	15.692807	24.901934	2.313079	1.245743
Trans. Margins	0.000000	0.000000	9.824643	4.694147	2.066479	0.000000	3.064019
Uper. Off. & Lab.	0.000000	0.000000	18.176464	15.378079	2.798385	0.000000	0.000000
Travel. Prom. Adv.	0.000000	0.000000	9.660584	8.494917	1.165667	0.000000	0.000000
Government	4.584573	39.700966					
TOTAL	86.551170	168.077576					

Source file: 04-05-1986 B:SMALL80.M7B 16*10 Canada 1980
Simulation: 06-06-1986 Eliminated export levies; revenue falls.

PRICES AND FINAL DEMANDS BY HOUSEHOLDS AND GOVERNMENT

INDUSTRY	CONSUMER PRICE	PRODUCER PRICE	CONSUMER 1	CONSUMER 2	CONSUMER 3	CONSUMER 4	CONSUMER 5
Agriculture	0.999264	1.000550	0.071867	0.108228	0.136573	0.161639	0.174635
Forestry	1.000777	1.000513	0.007446	0.010199	0.011697	0.013651	0.015487
Fish. Hunt. & Trap.	0.999353	1.000607	0.000894	0.001366	0.001716	0.002091	0.002284
Mining	1.006324	1.001214	0.089169	0.120768	0.136870	0.148504	0.163061
Manufacturing	1.152992	0.998352	2.425993	3.734769	4.912343	5.823350	6.498673
Construction	0.999658	0.999659	1.513391	1.971731	2.582819	2.674352	2.813425
Transport	1.010333	1.000527	0.213895	0.293926	0.350379	0.388409	0.416372
Communication	1.064985	1.001545	0.149685	0.207906	0.252789	0.284336	0.305912
Utilities	1.006358	1.001146	0.252205	0.332051	0.344406	0.371043	0.413071
Wholesale Trade	1.004467	1.001277	0.267647	0.407731	0.533595	0.627837	0.698466
Retail Trade	1.001442	1.001439	0.614148	1.012159	1.355200	1.687357	1.927343
F.I.R.E.	1.001611	1.001786	1.883770	2.457728	2.958691	3.450188	3.892402
Services	1.009784	1.001014	0.515363	0.800452	1.181666	1.566601	1.832837
Trans. Margins	1.000329	1.000329	0.063555	0.099175	0.131491	0.156981	0.175485
Uper. Off. & Lab.	0.996980	0.996980	0.014330	0.022093	0.029644	0.037529	0.042651
Travel. Prom. Adv.	0.999539	0.999539	0.006017	0.009388	0.012617	0.016157	0.018431

Source file: 04-05-1986 B:SMALL80.M7B 16*10 Canada 1980
Simulation: 06-06-1986 Eliminated export levies; revenue falls.

FINAL DEMANDS BY HOUSEHOLDS AND GOVERNMENT (Concl.)

INDUSTRY	CONSUMER 6	CONSUMER 7	CONSUMER 8	CONSUMER 9	CONSUMER 10	GOVERNMENT	TOTAL DEMAND
Agriculture	0.193276	0.212562	0.217401	0.241401	0.238113	0.017097	1.772793
Forestry	0.017550	0.019525	0.021264	0.024568	0.030980	0.000000	0.172366
Fish. Hunt. & Trap.	0.002511	0.002808	0.002833	0.003129	0.002665	0.000000	0.022298
Mining	0.186154	0.198732	0.215822	0.248389	0.396067	0.128410	2.031945
Manufacturing	7.360701	8.171830	9.032232	10.381938	16.323246	2.332291	76.997368
Construction	3.276865	3.602942	4.128006	5.184065	12.853597	1.563152	42.164345
Transport	0.444414	0.484505	0.535962	0.633203	0.843211	0.885555	5.489832
Communication	0.326718	0.356302	0.396637	0.468369	0.633621	0.666684	4.048959
Utilities	0.471961	0.495818	0.526404	0.579908	0.696789	0.000000	4.483656
Wholesale Trade	0.791297	0.873731	0.970500	1.117471	1.826516	0.225000	8.339790
Retail Trade	2.170796	2.426132	2.683620	3.025483	3.992714	0.169099	21.064049
F.I.R.E.	4.436568	4.807710	5.411074	5.930830	8.069041	0.366280	43.664284
Services	2.041185	2.347808	2.688127	3.166901	4.313644	4.447334	24.901918
Trans. Margins	0.198273	0.220181	0.242592	0.277892	0.420408	0.080447	2.066479
Oper. Off. & Lab.	0.047487	0.051661	0.058440	0.066614	0.093513	2.334423	2.798385
Travel. Prom. Adv.	0.020466	0.022253	0.025157	0.028527	0.038322	0.968333	1.165667

Source file: 04-05-1986 B:SMALL80.M7B 16*10 Canada 1980
Simulation: 06-06-1986 Eliminated export levies; revenue falls.

LEISURE, INCOME, AND WELFARE OF HOUSEHOLDS AND GOVERNMENT

CONSUMER	LEISURE	INCOME	DISPOSABLE	UTILITY	COMPENSATING VARIATION	EQUIVALENT VARIATION
		($ billions)	($ billions)		($ billions)	($ billions)
1	1.730420	3.450227	8.484206	9.799575	0.001208	0.001209
2	5.832642	5.817357	12.194771	17.385578	0.004131	0.004132
3	8.448706	9.309267	15.726786	23.331938	0.012514	0.012518
4	8.306535	13.966169	18.351772	25.661400	0.027386	0.027397
5	8.877525	18.246979	20.441565	28.207302	0.041649	0.041667
6	9.578610	23.076675	23.174799	31.486904	0.057256	0.057283
7	9.996732	27.252026	25.613947	34.206139	0.070817	0.070853
8	9.957400	32.827057	28.615517	37.021145	0.088697	0.088747
9	10.673700	40.688221	33.057121	41.947651	0.114867	0.114936
10	14.667255	73.046295	53.391010	65.276947	0.223213	0.223378
GOVERNMENT			58.544601	58.469601	-0.294154	-0.293777
TOTAL	88.069519	247.680267	297.596100		0.347584	0.348343

CAPITAL INCOME OF NON-RESIDENTS 7.501906 NON-RESIDENT WITHHOLDING TAX RATE .1406577

G.N.P.	296.8215
AFTER TAX RENTAL PRICE OF CAPITAL	1.002621
WAGE RATE	1.001943
PRICE INDEX	100
EXCHANGE RATE	.9890059

Source file: 04-05-1986 B:SMALL80.M7B 16*10 Canada 1980
Simulation: 06-06-1986 Eliminated export levies; revenue falls.

MODEL 7 by S. Damus (c) 1986, Economic Council of Canada.

TAX REVENUE BY SOURCE	$ billions
CORPORATE INCOME	11.557139
SOCIAL SECURITY	4.861630
MUNICIPAL PROPERTY	9.575589
ROYALTIES	5.544754
FINAL SALES	12.298843
INTERMEDIATE SALES	5.066597
OTHER COMMODITY	-3.086049
DUTIES	3.042092
EXPORT LEVIES	0.000000
PERSONAL INCOME	32.298790
NON-RESIDENT WITHHOLDING	1.055201
TOTAL	82.214592

Marginal cost of taxes EV: 1.133825 CV: 1.131354

Source file: 04-05-1986 B:SMALL80.M7B 16*10 Canada 1980
Simulation: 06-06-1986 Eliminated export levies; revenue falls.

TAX RATES

INDUSTRY	CORPORATE	LABOR	PROPERTY	ROYALTIES	FINAL SALES	OTHER V.A.	DUTIES	EXPORTS
Agriculture	0.01292	0.00777	0.06570	0.0	0.00040	-.02887	0.01579	0.0
Forestry	0.12021	0.02461	0.08909	0.09312	0.00054	-.00187	0.00154	0.0
Fish. Hunt. & Trap.	0.02814	0.01475	0.01796	0.0	0.0	-.01594	0.00140	0.0
Mining	0.16454	0.03981	0.03880	0.14911	0.00597	0.00516	0.00113	0.0
Manufacturing	0.32178	0.04075	0.04936	0.00041	0.15859	-.02878	0.05273	0.0
Construction	0.08408	0.03839	0.03655	0.0	0.0	0.02603	0.00110	0.0
Transport	0.10832	0.03848	0.09608	0.0	0.01040	-.01496	0.00466	0.0
Communication	0.13801	0.03918	0.06877	0.0	0.06389	-.04115	0.03651	0.0
Utilities	0.01552	0.03887	0.03114	0.00514	0.00523	-.02572	0.00042	0.0
Wholesale Trade	0.45928	0.04035	0.06076	0.00019	0.00366	0.00483	0.02662	0.0
Retail Trade	0.20780	0.03845	0.09015	0.0	0.00003	0.00740	0.01243	0.0
F.I.R.E.	0.06142	0.04112	0.28273	0.0	0.00000	0.01048	0.00005	0.0
Services	0.12334	0.03343	0.04564	0.0	0.00904	0.00059	0.00016	0.0
Trans. Margins	0.0	0.0	0.0	0.0	0.0	-.00711	0.0	0.0
Oper. Off. & Lab.	0.0	0.0	0.0	0.0	0.0	0.04815	0.0	0.0
Travel. Prom. Adv.	0.0	0.0	0.0	0.0	0.0	0.03146	0.0	0.0

PERSONAL INCOME TAX: -1.723726 + .2 * Y

Source file: 04-05-1986 B:SMALL80.M7B 16*10 Canada 1980
Simulation: 06-06-1986 Eliminated export levies; revenue falls.

MODEL 7 by S. Damus (c) 1986, Economic Council of Canada.

TAXES ON INTERMEDIATE INPUTS

	Industry 1	Industry 2	Industry 3	Industry 4	Industry 5	Industry 6	Industry 7	Industry 8	Industry 9
1 Agriculture	0.000074	0.0	0.0	0.0	0.000084	0.000217	0.000213	0.0	0.0
2 Forestry	0.000352	0.000001	0.019393	0.003969	0.000055	0.008229	0.001845	0.002374	0.000459
3 Fish. Hunt. & Trap.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 Mining	0.002337	0.015847	0.011361	0.001039	0.034383	0.001081	0.014690	0.011562	0.001233
5 Manufacturing	0.049848	0.157398	0.098650	0.083520	0.021588	0.032675	0.155024	0.066663	0.235111
6 Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 Transport	0.006022	0.007100	0.012360	0.006669	0.003688	0.006898	0.006826	0.007022	0.002556
8 Communication	0.047270	0.044739	0.044395	0.041421	0.041039	0.039248	0.048368	0.029227	0.031192
9 Utilities	0.019785	0.013559	0.015981	0.019263	0.017265	0.013427	0.017504	0.019611	0.020157
10 Wholesale Trade	0.000584	0.000362	0.001218	0.001069	0.001551	0.001159	0.000245	0.002399	0.000049
11 Retail Trade	0.000065	0.000101	0.000636	0.000032	0.000203	0.000085	0.000071	0.000020	0.000003
12 F.I.R.E.	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
13 Services	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.025220	0.000000
14 Trans. Margins	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15 Oper. Off. & Lab.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16 Travel. Prom. Adv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TAXES ON INTERMEDIATE INPUTS

	Industry 10	Industry 11	Industry 12	Industry 13	Industry 14	Industry 15	Industry 16
1 Agriculture	0.000012	0.0	0.0	0.000198	0.0	0.000194	0.0
2 Forestry	0.000289	0.002818	0.000136	0.001762	0.007106	0.001629	0.000207
3 Fish. Hunt. & Trap.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4 Mining	0.016649	0.010414	0.009212	0.008604	0.0	0.019791	0.008270
5 Manufacturing	0.115018	0.112806	0.141888	0.036586	0.0	0.030371	0.076300
6 Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 Transport	0.006811	0.005813	0.001289	0.005671	0.007106	0.000279	0.007037
8 Communication	0.040874	0.025417	0.041266	0.045083	0.0	0.033101	0.006878
9 Utilities	0.019557	0.018642	0.015982	0.018464	0.0	0.000001	0.000003
10 Wholesale Trade	0.000302	0.000913	0.000079	0.000876	0.0	0.001044	0.000895
11 Retail Trade	0.000058	0.000023	0.000001	0.000045	0.007106	0.000011	0.000042
12 F.I.R.E.	0.000000	0.000000	0.000000	0.000000	0.007106	0.0	0.000011
13 Services	0.000000	0.000000	0.000000	0.009201	0.007106	0.0	0.001054
14 Trans. Margins	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15 Oper. Off. & Lab.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16 Travel. Prom. Adv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source file: 04-05-1986 B:SMALL80.M7B 16*10 Canada 1980
Simulation: 06-06-1986 Eliminated export levies: revenue falls.

BIBLIOGRAPHY

Appelbaum, E. and V. R. Kohli, "Canada-US Trade: Tests for the Small-Open-Economy Hypothesis," Canadian Journal of Economics, vol. 12, 1979, pp. 1-14.

Armington, P. S., "A Theory of Demand for Products Distinguished by Place of Production," I.M.F. Staff Papers, vol. 16, 1969, pp. 159-176.

Ballentine, J. G. and W. R. Thirsk, The Fiscal Incidence of Some Experiments in Fiscal Federalism, Technical Report, Minister of Supply and Services, Canada, 1979.

Boadway, R. W. and J. M. Treddenick, The Impact of the Canadian Mining Industries on the Canadian Economy, Centre for Resource Studies, Queen's University, Kingston, 1977.

Burgess, David F., "Toward an Estimate of the Importance of Terms of Trade Effects for the Cost of External Funding to Canada," paper prepared for the Economic Council of Canada, October 17, 1985, mimeo.

Cloutier, Eden, "Taxes and the Labour Supply of Married Women in Canada," Economic Council of Canada, Discussion Paper No. 305, May 1986.

Damus, S., Government Loan Subsidies, Economic Council of Canada: Minister of Supply and Services, 1984.

Damus, S., P. Hobson and W. R. Thirsk, "The Welfare Effects of Property Taxation in an Open Economy," paper presented to the Canadian Economic Association, Winnipeg, May 30, 1986.

Hamilton, R. and J. Whalley, "Tax Treatment of Housing and a Dynamic Sequenced General Equilibrium Model," Journal of Public Economics, vol. 27, 1985, pp. 157-175.

Harris, R. G. and D. Cox, Trade, Industrial Policy, and Canadian Manufacturing, Toronto: Ontario Economic Council, 1984.

Hood, R., G. Glenday and J. C. Evans, "The Estimation of a Social Discount Rate for Canada: A Stock Adjustment Model with Country Risk," Department of Finance, Corporate Finance Division, mimeo, January 1982, unpublished.

Jenkins, G. P. and C.-Y. Kuo, "On Measuring the Social Opportunity Cost of Foreign Exchange," Canadian Journal of Economics, vol. 18, 1985, pp. 400-415.

Krauss, M. B. and H. G. Johnson, "The Theory of Tax and Expenditure Incidence: A Diagrammatic Analysis," Public Finance, vol. 31, 1976, pp. 340-375.

Leipziger, D. M., "Capital Movements and Economic Policy: Canada Under a Flexible Exchange Rate," Canadian Journal of Economics, vol. 7, 1974, pp. 59-74.

Norrie, K. H. and M. B. Percy, "Economic Rents, Province-Building and Interregional Adjustment: A Two-Regional General Equilibrium Analysis," Economic Council of Canada, Discussion Paper No. 230, April 1983.